**AMENDMENTS TO THE DRAWINGS:**

The attached drawing sheets include amended and marked-up versions of Figures 3, 15 and 16. Figure 3 is amended to correct an error in the spelling of the word "Network". Figures 15 and 16 are amended to include a numerical designation for the entire structure shown in each Figure.

Attachments: Marked-up version of Figures 3, 15 and 16 are included at Appendix A.

Clean "Replacement Sheets" for amended Figures 3, 15 and 16 are included at Appendix B.

## REMARKS

Claims 1-9, 11-23 and 26-33 are pending in the application.

Independent claims 1 and 16 are amended above to more clearly set forth what the applicant regards as the invention. Independent claims 3-6, and 11-14, 18-21, 26-30 and 33 are amended to conform their language to the language used in amended claims 1 and 16. The specification is amended to correct a typographical error. Figures 3 and 15-16 are amended to correct a typographical error and to add missing figure designations. No new matter is added to the specification or claims by these amendments.

## I. THE INVENTION

Before discussing the prior art rejections the applicant wishes to review phased arrays and the problems solved by the claimed invention. Conventional phased arrays require array antenna elements to have drive signals which vary in phase relative to one another approximately with position across the array from an array edge. The relative variance need not be accurately linear, and indeed some departure from linearity ("phase taper") is often useful to give particular beam properties.

Applicant's invention is directed to solving a serious prior art dilemma associated with designing mast-mounted antenna array assemblies with electrical control of beam tilt. The dilemma is where to locate the variable phase shifters. There are generally two choices for locating the variable phase shifters - both of which are problematic. U.S. Patent No. 6,573,875 to Zimmerman is a good example of this dilemma. One may, as in Zimmerman, locate the phase shifters which control electrical tilt in the antenna assembly. In this location, the phase shifters are high in the air at an antenna mast head where they are not accessible for adjustment without considerable labour and expense (requiring e.g. ladders, scaffolding or a mobile crane). The alternative is to locate the phase shifters remotely from the antennas in a base station, in which case one has to send many feeder cables up the mast from each phase shifter to each antenna, i.e. a respective feeder cable for each individual signal phase. It is a long-felt need to avoid <u>both</u> of these location alternatives and their respective disadvantages: i.e. one does not want either to install relatively inaccessible phase shifters at a mast head or to send many feeder cables up the mast.

The provision of many feeder cables is a problem because they are a source of considerable expense, weight and phase errors. This is because each feeder cable must extend from a ground level base station to an antenna assembly on a mast, which in the USA for example is typically in the range 100 to 330 feet high. This second location alternative requires extra cable as well as a stronger supporting mast to support the extra cable weight. Another problem with multiple feeder cables is that phase errors are introduced by different feeder cable environments; i.e. some feeders may be in shadow, others in direct sunlight, some may be wet with rain or covered in snow, and others may be partly or wholly sheltered. This leads to differences in thermal expansion and phase changes along feeder. Thus, an antenna assembly which is correctly adjusted initially goes out of adjustment as the weather changes, and even as the sun crosses the sky. The motivation for mounting phase shifters inconveniently with the antenna assembly as in Zimmerman where they cannot be adjusted easily is precisely to avoid the problems associated with sending many feeder cables up a mast.

Applicant's invention overcomes these problems. Indeed, in one embodiment, the invention only needs one feeder cable. Another embodiment only needs two feeder cables each carrying a respective signal with a single phase difference between these signals controlling antenna tilt. Applicants' invention does not need (N-1) feeder cables for N antenna elements, and yet it still provides antenna element drive signals which vary progressively in phase across an array and which are all adjustable to change electrical tilt in response to a single variable phase shifter.

Applicant's invention, as now claimed in independent claims 1 and 16, solves the problems mentioned above by splitting a primary signal into first and second signals **A** and **B** between which a relative phase shift is introduced, splitting each of the first and second signals into first and second component signals respectively, and thereafter combining each of the first and second signals with the other signal's component signals to provide antenna element drive signals. (See Applicant's specification at page 20 line 8 to page 22 line 17). Signals **A** and **B** are then spilt into components of the kind $a_i\mathbf{A}$ and $b_i\mathbf{B}$. In the example described with reference to Tables 1 and 2 for a phased array with ten antenna elements, $a_i$ and $b_i$ take values 0, $\pm$ 0.32 and $\pm$ 0.73. So $\mathbf{A} + b_i\mathbf{B}$ and $\mathbf{B} + a_i\mathbf{A}$ are formed. This provides ten different antenna element drive signals varying in phase progressively across the array with antenna element position as required

for phased array operation. Moreover, altering the relative phase shift between the signals **A** and **B** changes the angle of electrical tilt of the array. In this manner, the claimed system is able to remotely control beam tilt in an antenna array using one or two feeder cases.

## II. THE ANTICIPATION REJECTION

The Examiner rejected claims 1, 5, 11, 16, 20, 26 under 35 U.S.C. 102(e) as being anticipated by Shapira (2006/0068848). Regarding independent claims 1 and 16, the Examiner states that Shapira discloses: a phased array pair (Abstract) with adjustable electrical tilt (paragraph 0017) and having an array of antenna elements (Abstract) incorporating a) variable phase shifter (paragraph 0058) for introducing relative phase shift between first and second signals (Fig. 3), b) splitting apparatus (38) for dividing the relatively phase shifted first and second signals into component signals and c) a signal combining network for forming vectorial (a phase difference is a vector difference) combinations of the component signals to provide respective signal for each antenna element with corresponding angle of electrical tilt to phase shift (paragraph 0017).

The examiner's anticipation rejection is traversed for several reasons. A first reason is because Shapira does not disclose every feature of amended independent claims 1 and 16. Unlike Applicant's invention as now claimed in independent claims 1 and 16, Shapira does not disclose the claimed features of dividing the first and second signals into first and second component signals, and forming vectorial combinations of (a) first component signals with the second signal and (b) second component signals with the first signal to provide individual antenna elements' drive signals varying in phase progressively across the array as a function of antenna element position as required for phased array operation, the angle of electrical tilt of the array being adjustable in response to alteration of the variable relative phase shift introduced by the variable phase shifter. The Examiner's reference to Shapira's splitter or divider (38) as being Applicant's claimed splitting apparatus is mistaken. The purpose of splitter (38) is stated at Shapira's paragraph 60 to be splitting the transmit signal into main and (transmit) diversity branches, i.e. the transmit signal is split into two signals which are then transmitted from different antennas. Shapira's split or component signals are therefore not combined with other signals as the claims require. As discussed above, Applicant's specification Figure 5 and Table 2

at page 21 both show how individual antenna elements' drive signals are produced from various linear combinations of two signals **A** and **B** with a relative phase shift between them. Claims 1, 5, 11, 16, 20 and 26 are novel at least because Shapira discloses nothing remotely resembling these claimed features.

Claims 1, 5, 11, 16, 20 and 26 are also novel because the examiner's rejection is based upon a misinterpretation of Shapira's teachings. Specifically, Shapira is not related to controlling electric tilt as the examiner believes. In Shapira's Abstract, a phased array pair is used for control of beam shape, not electrical tilt. In this regard the last sentence of Shapira's Abstract states that the pair is steerable together or apart to provide a narrow or broad beam. Shapira's paragraph 0017 regarding electrical tilting is a complete *non sequitur*, because it refers to "the beam steering control" for which there is no antecedent. Shapiro claim 9 likewise refers to "said beam steering control", but there is no beam steering control in claim 1 from which claim 9 depends. Moreover, Shapira's paragraph 96 makes it clear that electrical tilt or squint is an optional feature which requires additional phase shifters.[1] There is, however, no detailed disclosure of how electrical tilt is achieved in Shapira. The only disclosure remotely related to achieving electrical tilt is found in paragraph 98 describing Fig. 13, which indicates squint control is achieved in some unspecified way using phase shifters in dual beamers. Therefore, claims 1, 5, 11, 16, 20 and 26 are novel because Shapira is unrelated to controlling electric tilt.

Claims 5, 11, 20 and 26 are further independently novel over Shapira. Regarding claims 5, 11, 20, 26, the Examiner states that Shapira discloses a splitting apparatus (38) divides component signal for input to the signal phase shifting (26, 28) and combining network (20) in Fig. 3. This rejection is also premised upon a misunderstanding of Shapira's teachings. Feature (20) in Shapira Fig. 3 is not a combining network. Feature (20) is a dual polarised antenna column. (*See* paragraph 56 eighth line). Moreover, antenna column (20) does not combine signals. As indicated in paragraph 62, elements of the same polarisation, i.e. two right pointing arrows for one polarisation and two left pointing arrows for the other polarisation each provide a phased array pair giving two beams of different polarization. The two beams are both steerable by means of the phase shifters (26) and (28), each of which introduces a variable relative phase shift between a respective pair of signals associated with a respective polarisation. If antenna

[1] Note that RET in this excerpt is a term of art meaning remote electrical tilt control.

column (20) were to combine signals as stated by the Examiner, it would be impossible to steer beams as described in Shapira's paragraph 62. This is because one needs a minimum of two signals fed to different antenna elements with a variable relative phase shift between them in order to steer a beam using phased array principles. Combining signals in antenna column (20) would result in only one signal per beam. For at least this reason claims 5, 11, 20 and 26 are independently novel over Shapira.

## III. THE OBVIOUSNESS REJECTIONS

### A. The Shapira Obviousness Rejection

The Examiner rejected claims 12-13 and 27-28 under 35 U.S.C. 103(a) as being unpatentable over Shapira. Claims 12-13 and 27-28 are non-obvious and patentable by virtue of their dependency upon allowable independent claims 1 and 16.

Claims 12 and 27 are also independently non-obvious and patentable. Regarding claims 12 and 27, the Examiner notes that Shapira fails to specifically disclose the use of first, second and third splitters and collocated second and third splitters. The examiner's reference to claim 27 is not understood because claim 27 does not mention splitters. The rejection with respect to claim 27 is, therefore, without support.

The Examiner's rejection of claim 12 is based upon a misunderstanding of the claimed invention. Claim 12 is directed to the situation where electrical tilt is controlled remotely from the antenna assembly, e.g. in a base station on the ground instead of high in the air on a mast (see above RET = remote electrical tilt). Consequently splitting of the first and second signals and their relative phase shifting are implemented remotely, and two feeders are required to convey these signals to the antenna assembly. This feature of claim 12 is shown in Figure 12.

In connection with claim 12, the examiner alleges that it is known to split frequency carriers (say cellular and PCS band splitting), and that it would have been obvious to implement a first splitting of a primary signal before it is further split into a smaller frequency band. The claimed invention does not split frequencies. Therefore, whether or not it is obvious to split frequencies has no relevance whatsoever to the claimed invention. Moreover, claims 1 and 16 are amended above to stress that the invention starts with one signal and splits it to form the two signals which are then phase shifted relative to one another. All three signals, i.e. the one

primary signal which is split and the two resulting signals, have the same frequency. Therefore, claim 12 is non-obvious because it has nothing to do with splitting frequency as the examiner claims.

Claims 13 and 28 are likewise non-obvious over Shapira. Regarding claims 13 and 28, the examiner states that Shapira discloses a phased array antenna with a fixed phase shifter. (Shapira paragraph 0075 and feature (918) in FIG. 9). However, Shapira paragraph 0075 relates to Figure 8 and there is no feature (918) in Figure 8 or 9. Moreover, Figures 9A-9D do not show any phase shifter. Applicant assumes, therefore, that the examiner meant to refer to variable and fixed phase shifters (108) and (109) in Figure 8.

The Examiner acknowledges that Shapira fails to specifically disclose use of a first variable phase shifter connected in a transmit mode and a second variable phase shifter connected in receive mode. He goes on to state that it is common practice in a cellular base station having a TX antenna and an RX antenna separately. This observation is not relevant at least because claim 13 does not relate to separate TX and RX antennas. Instead, claims 13 and 28 are directed a single antenna that is used for both transmit and receive with independent tilt control in both cases. (See specification at page 35 line 3 to page 36 line 9). This feature of the claims is also shown in Figure 13, and it operates in TX and RX modes with only one antenna array (262). For at least this reason, the examiner's basis for rejecting claims 13 and 28 over Shapira is technically faulty so the rejection must be withdrawn.

**B. The Shapira and Thomas Obviousness Rejection**

The Examiner rejected claims 14-15 and 29-30 under 35 U.S.C. 103(a) as being unpatentable over Shapira in view of Thomas (2004/0252055). As an initial matter, the rejected claims are all patentable by virtue of their dependence upon independent claims 1 or 16 which are patentable for the reasons recited in Section II above.

Regarding claim 14, the Examiner acknowledges that Shapira fails to disclose a plurality of variable phase shifters associated with respective operators and filtering. The examiner relies upon Thomas for teaching the use of filtering (paragraph 0009) and variable phase shifter associated with respective operator (two for each operator) (paragraph 0170 & Figure 14) and a tilt control unit (704). However, Thomas paragraph 0170 relates to Figure 11, not Figure 14, and neither Figure 11 nor Figure 14 uses filters for the reason given in paragraph 0009 – i.e. because

filters do not work acceptably when operator frequencies are close together ("contiguous"). Therefore the technical basis for the examiner's rejection of claim 14 is faulty and the rejection must be withdrawn.

The Examiner's allegation that it would have been obvious to modify Shapira with Thomas by incorporating filtering and corresponding variable phase shifter, tilt control processing for respective operator in order to extract the wanted signal frequency and be capable of individually control *[sic]* each operator 's tilt requirement in transmit or receive mode is also faulty. The Applicant asserts that it is impossible to combine Shapira with Thomas because they have totally different objectives and implementations. Shapira (*See* e.g. Abstract) relates to a phased array pair (two elements only) steerable together with another such beam of different polarisation to form a narrow beam or steerable apart to form a wide beam. Shapira is not concerned with electrical tilt except as an optional extra (paragraph 0096). Thomas relates to signal combining for sharing of a phased array (e.g. twelve antenna elements Figure 8a) by multiple operators with different operating frequencies and independently adjustable angles of electrical tilt. Shapira discloses a single beam with a single frequency for each sector. Shapira therefore has no use whatsoever for signal combining, filters, multiple operating frequencies or independently adjustable angles of electrical tilt. Applicant respectfully submits that Shapira and Thomas are unrelated and not properly combinable to reach the claimed invention. For this reason, the examiner's rejection of claims 14-15 and 25-30 for obvious must be withdrawn.

Turning now to claim 15, Shapira fails to disclose respective pairs of variable phase shifters for multiple operators because Shapira has only one operator per phased array pair and cannot usefully employ them. Shapira discloses a single beam per phased array pair, and cannot incorporate multiple pairs of variable phase shifters because it has no use for any such.

Claims 29-30 are the method claim equivalents of claims 14 and 15, and the claims are non-obvious and patentable for the same reasons as discussed above with respect to claims 14-15.

### C. The Shapira And Gordon Obviousness Rejection

The Examiner rejected claims 2, 6-7, 17, 21-22 under 35 U.S .C. 103(a) as being unpatentable over Shapira in view of Gordon (US 5,410,321). The Examiner acknowledges that Shapira fails to disclose use of an odd number of antenna elements (claims 2, 17), hybrid

couplers (claims 6, 21) or 180 degree hybrid couplers (claims 7, 22). However, the Examiner goes on to state that Gordon teaches the use of odd number antenna elements and 180 degree hybrid couplers for combining signal, and that it would have been obvious to modify Shapira with Gordon by incorporating a 180 degree hybrid coupler and odd number elements in order to reduce interference between antenna elements.

As an initial matter, the rejected claims are all patentable by virtue of their dependence upon independent claims 1 or 16 which are patentable for the reasons recited in Section II above.

Claims 2, 6-7, 17, 21-22 are also non-obvious and patentable as Shapira and Gordon are not properly combined. It is an essential element of Shapira that it employs a phased array pair and not an odd number of elements. Therefore, inserting the odd number of elements of Gordon into Shapira would make Shapira unworkable and the examiner's rejection therefore should be withdrawn.

The Examiner justifies modifying Shapira with Gordon on the basis that it will reduce interference between antenna elements. The examiner's justification is technically incorrect. Shapira does not have interference between antenna elements because Shapira employs a phased array pair carrying the same signal. Moreover, adding antenna elements and hybrid couplers has no affect whatsoever on interference between antenna elements. Therefore the examiner's justification for combining the references is technically faulty and the rejection of claims 2, 6-7, 17 and 21-22 must be withdrawn.

**D. The Shapira And Gordon Obviousness Rejection**

The Examiner rejected claims 3-4 and 18-19 under 35 U.S.C. 103(a) as being unpatentable over Shapira in view of Kuramoto (5,281,974). The Examiner acknowledges that Shapira fails to disclose the use of serial connection of first and second variable phase shifters (claim 3, 18) or a plurality of phase shifters such that some of the signals passed through all second variable phase shifters and some have not (claims 4, 19). The Examiner goes on to state that Kuramoto discloses use of first and second variable phase shifters and a plurality of variable phase shifters in Figure 2. The examiner further states that it would have been obvious to modify Shapira with Kuramoto in order to do impedance matching or reducing intermodulation noise.

As an initial matter, the rejected claims are all patentable by virtue of their dependence upon independent claims 1 or 16 which are patentable for the reasons recited in Section II above.

Claims 3-4 and 18-19 are also independently non-obvious and patentable over the combination of references. First off, adding further phase shifters to Shapira will have no affect whatsoever on impedance matching or reducing intermodulation noise. Therefore, the examiner's justification for combining Shapira with Kuramoto fails technically.

Secondly, Kuramoto's Figure 2 shows all signals going through the same number of variable phase shifters. In Kuramoto, all signals go through the third variable phase shifter 28, then either through the first variable phase shifter 21 or through the second variable phase shifter 22. This is not what is claimed in claims 3-4, 18-19. So claims 3-4 and 18-19 are non-obvious because the prior art does not disclose every claim feature.

Thirdly, it is an essential element of Shapira that it employs a phased array having two signals and therefore only one phase shift between them. Shapira therefore does not require additional variable phase shifters. Therefore, claims 3-4 and 18-19 are non-obvious because one skilled in the art at the time of the invention would not have combined Shapira with Kuramoto as the examiner has.

**E. The Shapira, Gordon and Boire Rejection**

The examiner rejected claims 8-9, 23, 31-33 under 35 U.S.C. 103(a) as being unpatentable over Shapira in view of Gordon and further in view of Boire (4749969). However, as set forth is Section III(D) above, Shapira and Gordon are not properly combined, because incorporating Gordon's odd number of elements into the Shapira device would make Shapira unworkable. Moreover, the rejected claims are all patentable by virtue of their dependence upon independent claims 1 or 16 which are patentable for the reasons recited in Section II above.

Regarding this rejection of claims 8-9, 23, 33, the examiner acknowledges that Shapira and Gordon fail to disclose ring hybrids with circumference $(n+1/2)/\lambda$, neighbouring ports separated by $\lambda/4$ ( claims 8, 23,33), and an input terminal with resistor for impedance matching (claims 9, 33). However, the Examiner states that Boire teaches a 180 degree hybrid ring phase shifting apparatus with $(1+½)\lambda$ and $\lambda/4$ spacing and resistor for impedance matching (column 3, lines 28-38). The Examiner goes on to state that it would have been obvious to further modify Shapira with Boire. However, at column 1 lines 11-12, Boire states that it is suitable for interface with hybrid micro-electronic structures. Absent the hindsight provided by knowledge

of Applicant's invention, there is no reason to look at micro-electronics to find circuit elements suitable for much higher power RF applications such as the claimed phased arrays.

As regards claims 31-32, the Examiner acknowledges that Shapira as further modified by Boire fails to disclose a hybrid designed to convert input signals into vector sum or difference. Because a hybrid can be and is in Applicant's Figure 16 used as a splitter, absent the hindsight provided by knowledge of Applicant's invention, it is not automatic that Boire provides vector sum or difference.

## CONCLUSION

Claims 1-9, 11-23 and 26-33 are pending in this application and are believed to be patentable for the reasons recited above. Favorable reconsideration and allowance of the pending application claims is, therefore, courteously solicited.

Respectfully submitted,

Date: January 30, 2008

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# Appendix A

## (Marked Up Sheets – Figures 3, 15 & 16)

Fig.3.

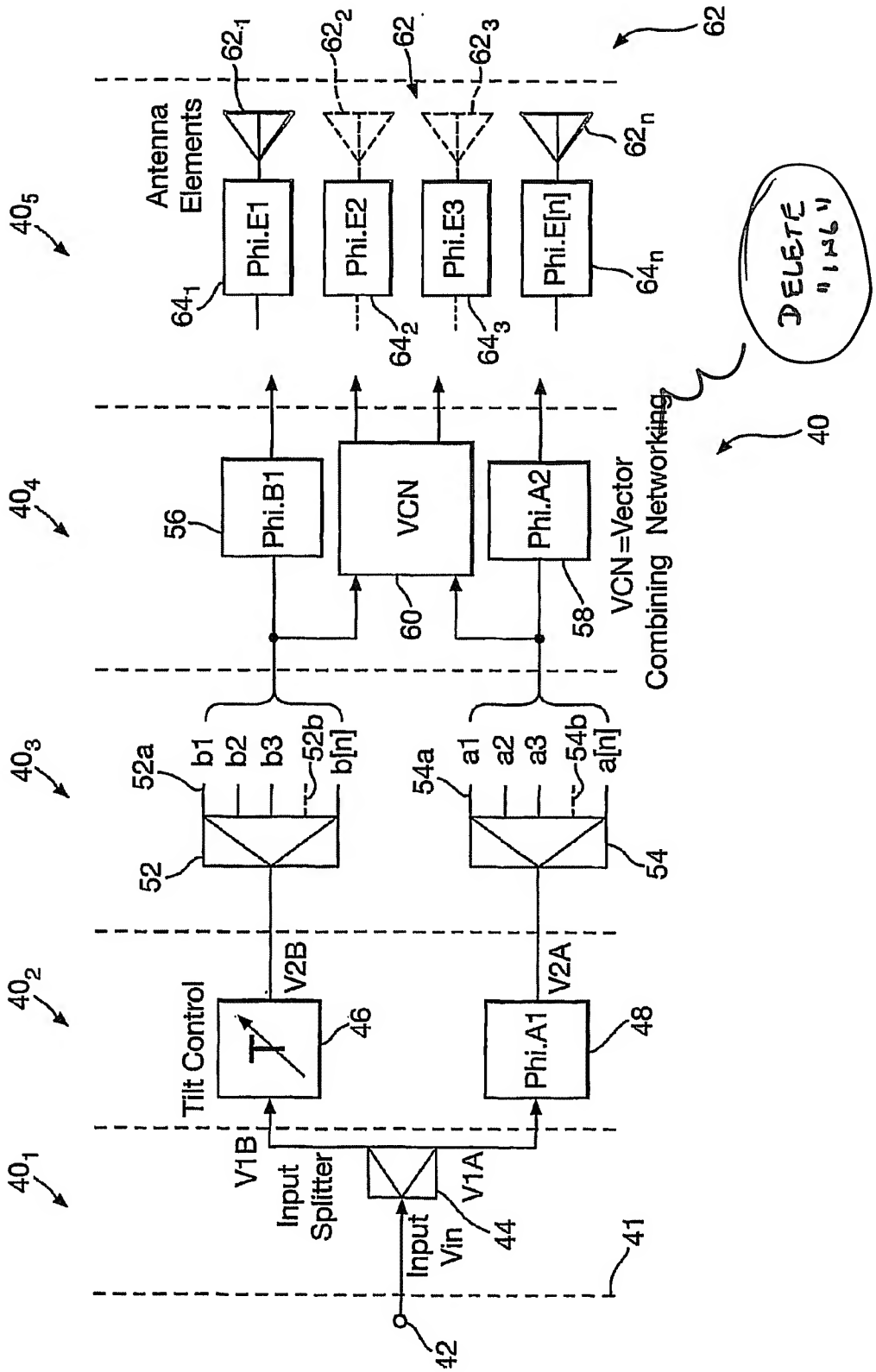
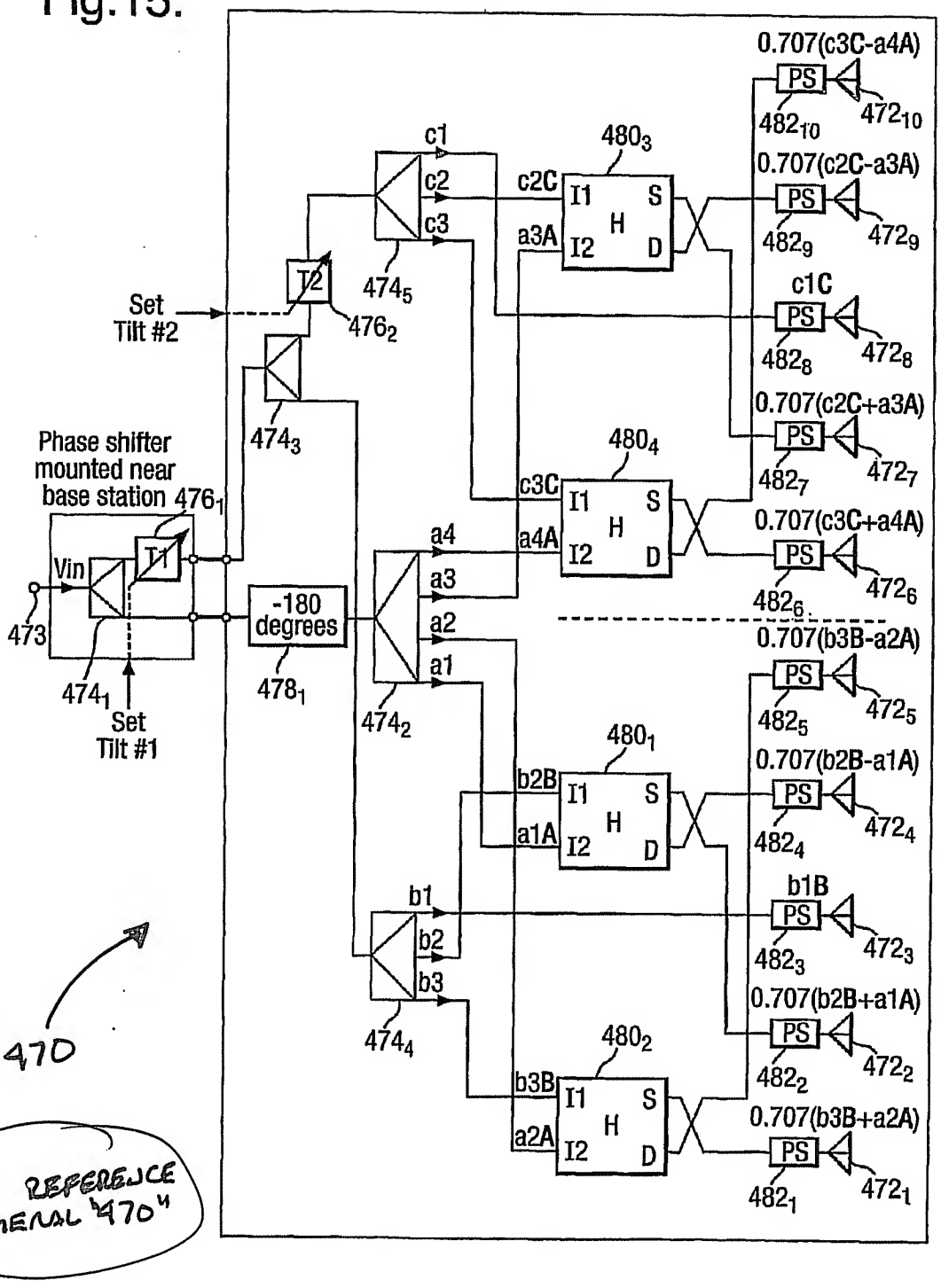

$40_1$
$40_2$
$40_3$
$40_4$
$40_5$
Input Vin
42
41
Input Splitter
V1B
V1A
44
Tilt Control
V2B
46
Phi.A1
V2A
48
52
52a
b1
b2
b3
52b
b[n]
54
54a
a1
a2
a3
54b
a[n]
56
Phi.B1
VCN
60
Phi.A2
58
VCN=Vector Combining Networking
40
Antenna Elements
$62_1$
$62_2$
62
$62_3$
$62_n$
62
Phi.E1
Phi.E2
Phi.E3
Phi.E[n]
$64_1$
$64_2$
$64_3$
$64_n$
DELETE

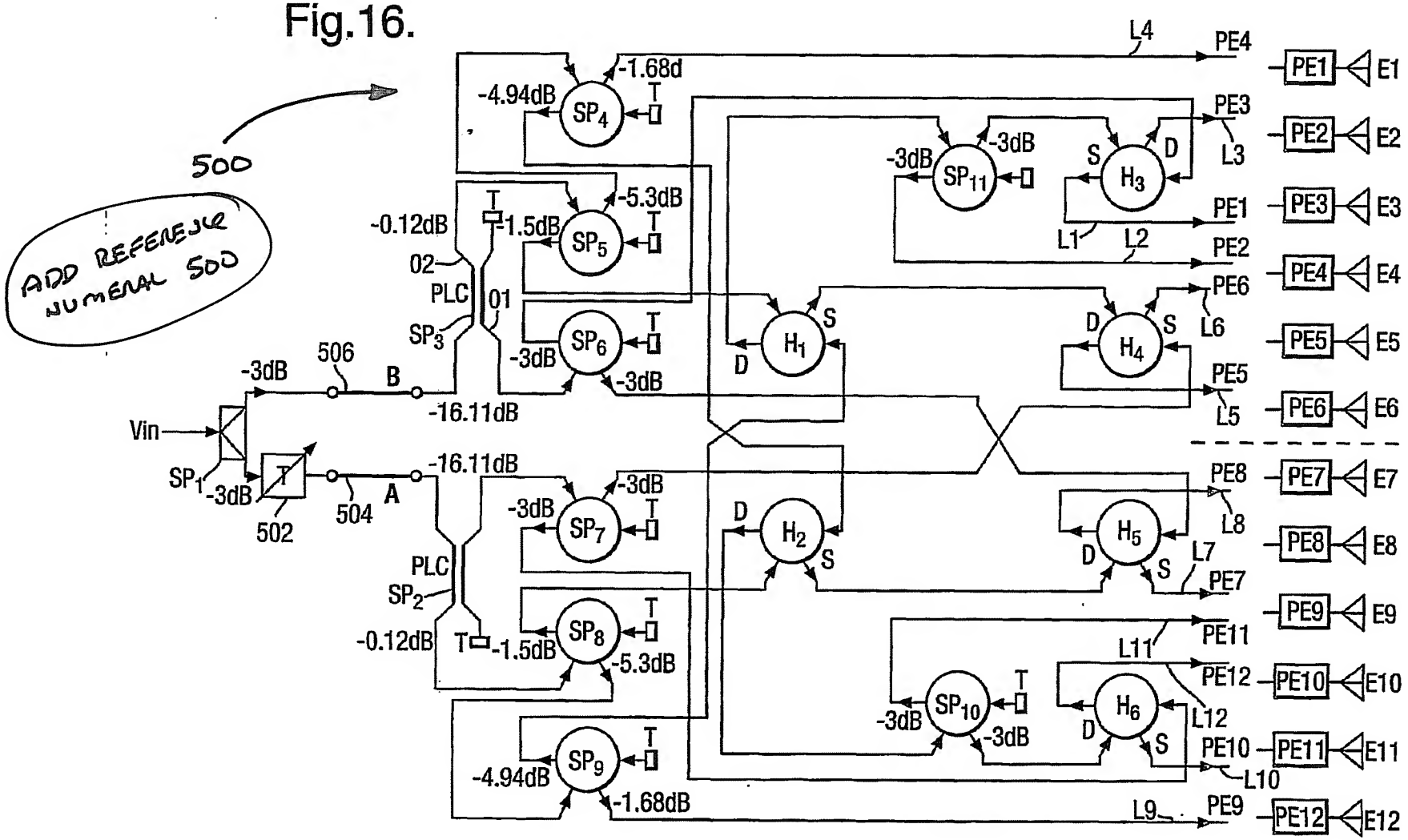
Fig.15.




470

ADD REFERENCE NUMERAL "470"

Fig.16.


500
ADD REFERENCE NUMERAL 500
Vin
SP1
-3dB
T
502
504
A
-16.11dB
506
B
-3dB
-16.11dB
PLC
SP3
02
01
-0.12dB
T
-1.5dB
SP5
-5.3dB
SP6
-3dB
-3dB
SP4
-4.94dB
-1.68d
PLC
SP2
-0.12dB
T
-1.5dB
SP8
-5.3dB
SP7
-3dB
-3dB
SP9
-4.94dB
-1.68dB
H1
H2
H3
H4
H5
H6
S
D
SP11
SP10
-3dB
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
PE1
PE2
PE3
PE4
PE5
PE6
PE7
PE8
PE9
PE10
PE11
PE12
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E8
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E10
E11
E12

# Appendix B

## (Replacement Sheets – Figures 3, 15 & 16)